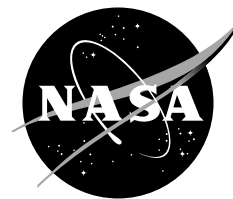# SimLab Overview

Aviation Systems Research, Technology & Simulation Division
Simulation Experiments Branch
Simulation Projects & Systems Branch
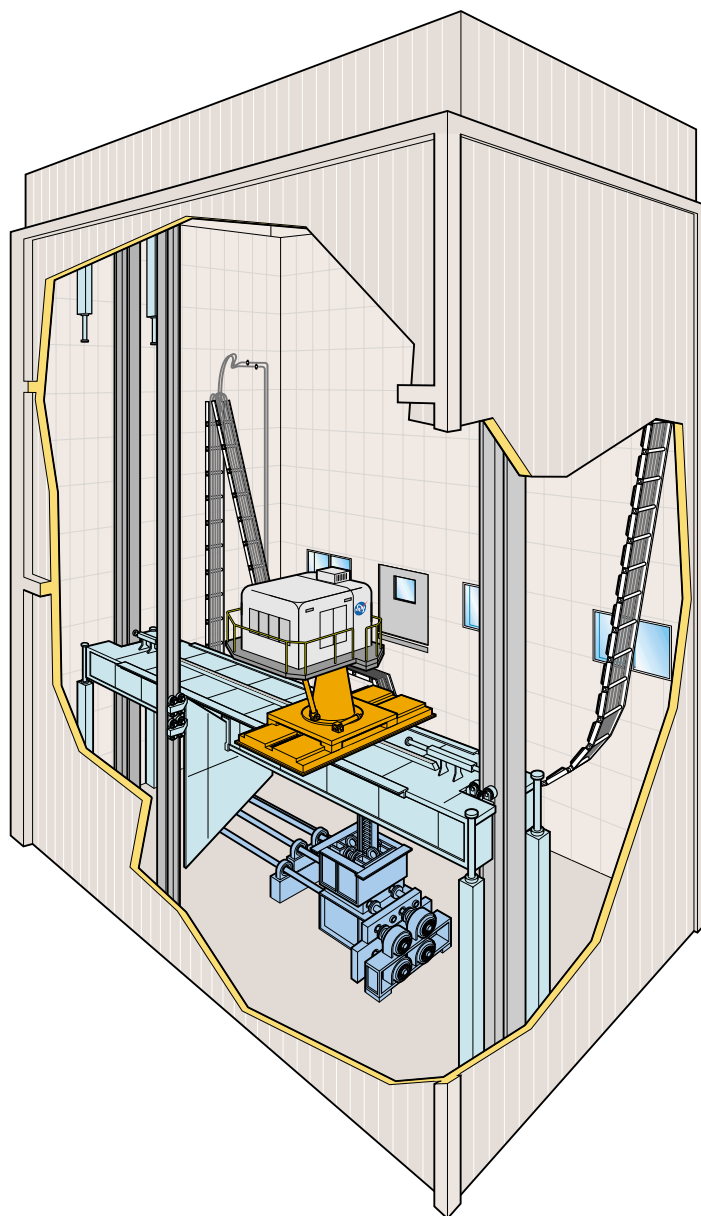
NASA Ames Research Center

Vertical Motion Simulator Research Facility

The Vertical Motion Simulator (VMS) is a world-class research and development facility that offers unparalleled capabilities for conducting some of the most exciting and challenging studies and experiments involving aeronautics and aerospace disciplines. The six-degree-of-freedom VMS, with its 60-foot vertical and 40-foot lateral motion capability, is the world's largest motion-base simulator. The large-amplitude motion system of the VMS was designed to aid in the study of helicopter and vertical/ short take-off landing (V/STOL) issues specifically relating to research in controls, guidance, displays, automation, and handling qualities of existing or proposed aircraft. It is also an excellent tool for investigating issues relevant to nap-of-the-earth flight, and landing and rollout studies.

Recent simulation projects developed and conducted at the VMS include High Speed Research (High Speed Civil Transport), Advanced Subsonic Transport/ Short-Haul Civil Transport (Civil TiltRotor), Common Affordable Lightweight Fighter (Advanced Short Take Off Vertical Landing) and Space Operations (Space Shuttle Orbiter).

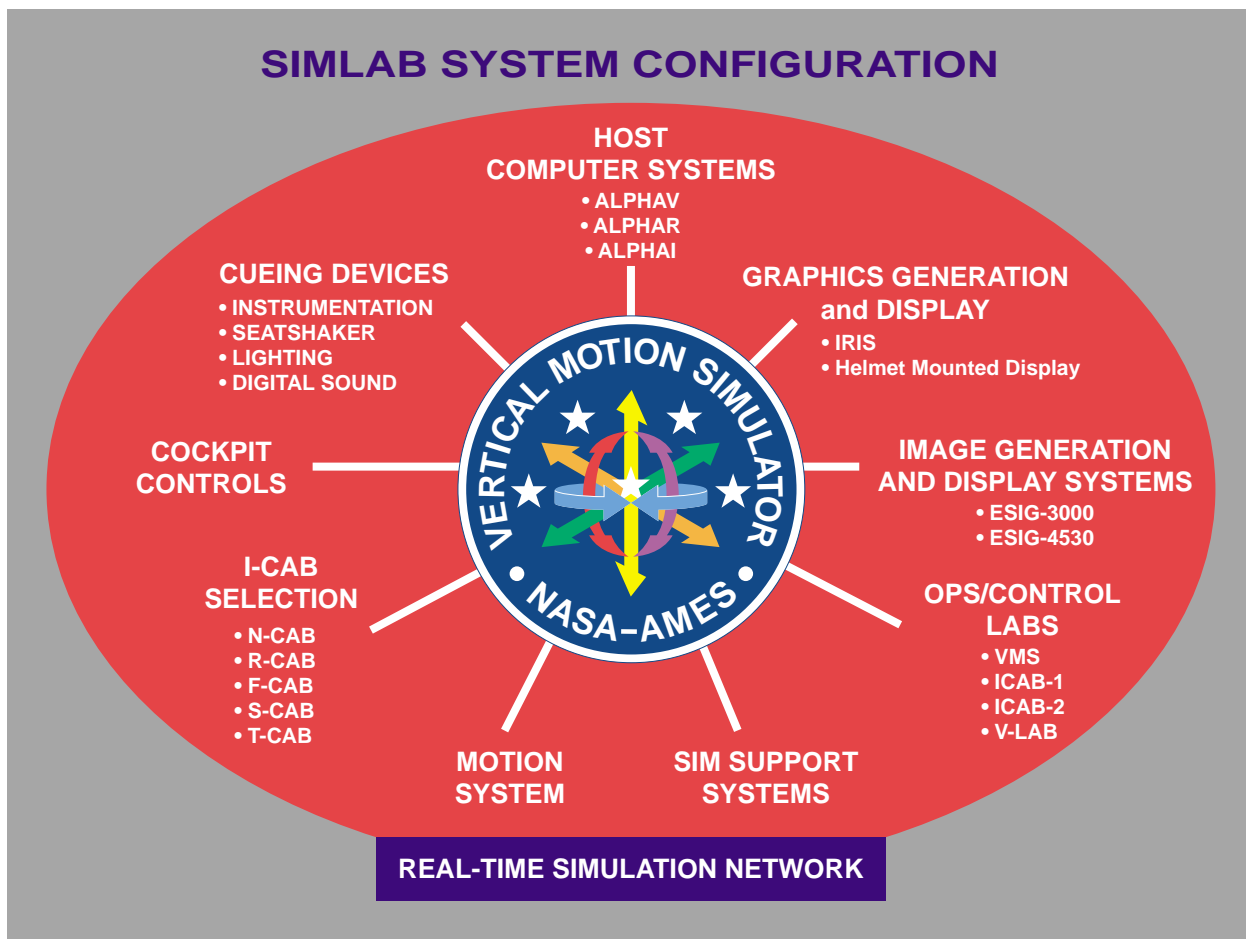*Cut-away view of the Vertical Motion Simulator Facility*

SIMLAB SYSTEM CONFIGURATION

HOST COMPUTER SYSTEMS
- ALPHAV
- ALPHAR
- ALPHAI

CUEING DEVICES
- INSTRUMENTATION
- SEATSHAKER
- LIGHTING
- DIGITAL SOUND

GRAPHICS GENERATION and DISPLAY
- IRIS
- Helmet Mounted Display

COCKPIT CONTROLS

VERTICAL MOTION SIMULATOR
NASA–AMES

IMAGE GENERATION AND DISPLAY SYSTEMS
- ESIG-3000
- ESIG-4530

I-CAB SELECTION
- N-CAB
- R-CAB
- F-CAB
- S-CAB
- T-CAB

OPS/CONTROL LABS
- VMS
- ICAB-1
- ICAB-2
- V-LAB

MOTION SYSTEM

SIM SUPPORT SYSTEMS

REAL-TIME SIMULATION NETWORK

Figure 1

Simulation System Description

The VMS, which is located in the Flight and Guidance Simulation Laboratory (SimLab) at NASA Ames Research Center, is renowned for its efficient production of high-fidelity, fixed and moving base, real-time, piloted flight simulations of aerospace vehicles. SimLab offers researchers, from the government and private industry, unique and powerful capabilities to investigate and resolve issues related to current aircraft as well as advanced flight vehicles in their design stages. This national facility is also used to develop new techniques for flight simulation and to define the requirements and develop technology for both training and research simulators.

It is important to appreciate that the very prominent large motion base of the VMS is only one part of SimLab's simulation system. The complete system, as depicted in *Figure 1*, consists of a collection of simulation subsystems working in concert via a real-time simulation network. Based on SimLab's operating philosophy of supporting the widest possible range of aeronautical research, the system can be configured by selecting and integrating the most appropriate of several interchangeable components to suit specific requirements of any simulation. This modular approach makes it easy to integrate specialized equipment for a particular simulation. Also, facility improvements can be implemented by upgrading individual components without disrupting operations of the entire simulator.

At the highest level, the simulation elements may be classified under the following functional categories: (i) Host computer, (ii) Interfaces, (iii) Test Operations and Control (Lab), (iv) Crew or Pilot Station (also known as the Cab), and (v) Cueing Systems. The basic concept of real-time

man-in-the-loop flight simulation may be described as follows. The pilot executes control actions which are transmitted to the host computer which calculates the aircraft response variables (states) and the corresponding drive signals for the cue-producing devices. The devices generate cues (visual, motion, sound) that stimulate the pilot's various sensory organs in a manner similar to what would occur in actual flight. Hence, the pilot receives the sensation of actual flight, and can evaluate the flying qualities of the simulated aircraft. Researchers and engineers interact with the real-time simulation flow from the devices in the lab. Examples of this interaction are starting and stopping a run, introducing a simulated failure and monitoring test data. Communication between the functional elements is achieved via several interface computers, devices or data links.

   Each of the functions described in the above paragraph is performed by one or more physical units.

   The Simulation Host Computer is the nucleus of the simulation system because it solves the equations which represent the mathematical model of the aircraft and it generates the signals to command and control all the other devices in the system. Most importantly, it does all this in real-time. This means that the equations are solved fast enough to allow the computed
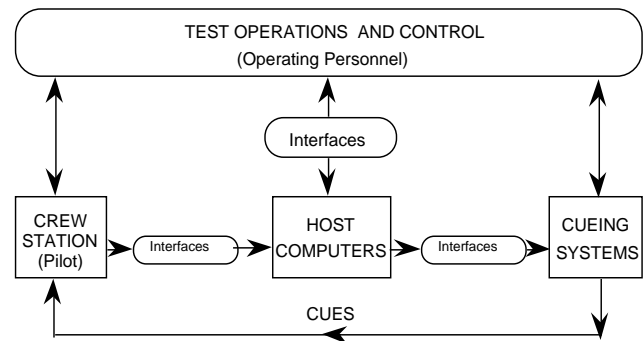
Figure 2 Simulator System Schematic Diagram

variables that are output to the simulator to be synchronized with real-world (wall-clock) time, which allows the pilot to interact with the simulator as though it were the actual aircraft. SimLab's three production hosts are AXP AlphaServer 1000/233 computers manufactured by Digital Equipment Corporation (DEC). These powerful systems can operate the motion, laboratory and cockpit sub-systems at a 200 Hz update rate.

   The Host Computer communicates with two other computer systems through a Real-Time Data Network :

   1. The CGI (Computer Generated Imagery) System, which generates the out-the-window (OTW) visual scene. SimLab uses two multi-channel, full-color CGIs to provide a variety of realistic OTW scenery: The ESIG-3000 and ESIG-4530 which are built by Evans and Sutherland. A library of configurable terrain databases in each of the CGIs gives researchers considerable flexibility with their experiments. *Figure 3* illustrates an ESIG-3000 generated OTW scene as viewed in a cab.

   2. The **HUD/HDD** graphics systems generate cockpit graphics as well as lab graphics displays. A family of Silicon Graphics Inc.'s IRIS computers is used for the generation of these displays.

Figure 3

The system description would be incomplete if there were no mention of the software running on the above mentioned hardware. On the Host Computer, the MicroTAU real-time operating system provides the backbone for all simulations. Also residing on the host are the application programs that represent the mathematical models of the aircraft and other auxiliary subsystems. On the CGI are the real-time image generation system software and the database for the OTW scenery. On the cockpit graphics systems reside the graphics generation programs for the cab and lab displays.

Interchangeable Cabs (I-Cabs)

The five I-CABs used with the VMS provide the capability to simulate the cockpit/crewstation for almost any imaginable aerospace vehicle. R-CAB and N-CAB are used for rotorcraft simulations, while F-CAB is suited for fighter aircraft. The S-CAB and T-CAB, with their two-place side-by-side cockpit, are ideal for simulating transport vehicles. The cabs can be equipped with either conventional aircraft panel instruments or advanced avionics (glass cockpits) displays. Pilot controls are connected to electrohydraulic loaders so that the control system parameters can be matched to those of the simulated aircraft. The cabs are configured, tested, and checked out at the fixed-base I-CAB development location before being moved to the motion platform. This pipeline approach provides maximum efficiency in the use of the motion system.

Other Cueing Devices

There are several other cueing devices besides the ones mentioned above. The **sound-simulation** system, provided by ASTi Digital Audio Communication System, can reproduce a wide variety of sounds associated with different types of aircraft, warning tones, and voice callouts. Six speakers are mounted in the cab to provide the audio spatial effects. The **vibration generator** (or seat shaker) is a mechanism that provides high-frequency, low amplitude accelerations which are characteristic of aircraft vibrations. Motion cues of this type are beyond the frequency response of the VMS motion system. The seat shaker unit can be fitted in the F-CAB, N-CAB or R-CAB. Another method to display aircraft information is the **Integrated Helmet and Display Sighting System** (IHADSS). It comes integrated with the head-tracking capability that was developed for use on the AH-64 Apache attack helicopter.

Examples of Research and Studies

Vehicles simulated at SimLab span the full spectrum of flight, ranging from the Shuttle orbiter and military fighters to various experimental fixed-wing, Vertical/Short Take-Off and Landing (V/STOL), Short Take-Off and Landing (STOL), Short Take-Off and Vertical Landing (STOVL), and rotorcraft designs. SimLab has contributed substantially to flight safety and aeronautical technology by refining and enhancing aircraft design, and improving handling qualities, reducing pilot workload, and providing information on advanced control laws and accident investigations.

For example, the VMS contributed to the U.S. Air Force C-17 Transport program by identifying design and performance issues before the aircraft was built. Also, the VMS is used twice a year to study landing and rollout of the Space Shuttle orbiter. SimLab gives the shuttle pilot-astronauts the opportunity to effectively practice landing scenarios or critical maneuver involving the orbiter. The simulator can provide worst-case scenarios for the pilot, such as blown tires, crosswinds, or failed auxiliary power units. The VMS has been critical for the study of drag-chute design and testing, tire wear, brakes, and crew evaluation and training.

For Further Information...

If you you have any questions please call Dave Jones, Associate Chief for Simulation at (650) 604-5853.

Or, visit us on the NASA Ames Homepage on the Internet. Our URL is:

http://www.simlabs.arc.nasa.gov/